AMPHIROA VAN-BOSSEAE (CORALLINALES, RHODOPHYTA) ON EUROPEAN ATLANTIC COASTS

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ABSTRACT – Specimens of *Amphiroa van-bosseae* Lemoine from several localities in the Atlantic coast of the Iberian Peninsula were studied. This is the first record of this Pacific species in the European Atlantic. Comparisons with the closely related species *A. rigida* Lamouroux and *A. beauvoisii* Lamouroux reveal clear distinctions. This study suggests that most reports of *Amphiroa* Lamouroux from European Atlantic coasts should be referred to *A. van-bosseae*.

RESUMÉ — Des spécimens d'*Amphiroa van-bosseae* Lemoine, en provenance de plusieurs localités des côtes atlantiques de la péninsule Ibérique ont été étudiés. Cette espèce du Pacifique est signalée pour la première fois sur les côtes atlantiques européennes. La comparaison avec les espèces européennes d'aspect similaire, *A. rigida* Lamouroux et *A. beauvoisii* Lamouroux, fait apparaître des différences anatomiques nettes. Cet étude permet d'affirmer que la plupart des mentions du genre *Amphiroa* Lamouroux sur les côtes atlantiques européennes doivent être rapportées à *A. van-bosseae*.

KEY WORDS: *Amphiroa van-bosseae*, *A. rigida*, *A. beauvoisii*, Corallinaceae, Rhodophyta, Atlantic Ocean, Iberian Peninsula, Biogeography, Systematics, Taxonomy.

INTRODUCTION

When sampling the Atlantic coasts of the Iberian Peninsula, particularly on the Galician coasts, we have often found a species of *Amphiroa* Lamouroux with very well-defined morphological and ecological characters. This species is now identified as *A van-bosseae* Lemoine (1929), a species originally described from the Pacific and which, under this name, has never been recorded elsewhere. However, we should note that *A. subcylindrica* Dawson (1953) was discovered on the Mauritanian coasts (Lawson & John, 1977) and, according to Norris & Johansen (1981), this species is conspecific with *A van-bosseae*. Because the habit of *A. van-bo sseae* is rather similar to that of other species of the genus cited from European Atlantic coasts, particularly *A. rigida* Lamouroux and *A. beauvoisii* Lamouroux, we have studied several herbarium sheets of these species to contribute to the knowledge of the distribution of *Amphiroa* on these coasts.

MATERIAL AND METHODS

The specimens collected were preserved in 4 % formalin-seawater and herbarium specimens were rehydrated for their study. For microscopic observations, selected fragments were decalcified using 25 % acetic acid and embedded in 10 % gelatine for 12h at 40° C. Then, they were extended on a slide, covered with liquid gelatine and dried 24h at room temperature. Dry longitudinal hand-made sections were soaked in distilled water, heated slightly for removing the gelatine and stained in Delafield's haematoxylin. For their observation and preservation semipermanent slides were prepared using 20-25 % aqueous Karo® corn-syrup. Studied specimens have been deposited at the herbarium of the University of Santiago de Compostela (SANT-*Algae*).

RESULTS

***Amphiroa van-bosseae* Lemoine 1929: 73.** Holotype: BM, "Galapagos, île Charles, Post Office Bay, août 1924". D.C. Crossland.

Description (Fig. 1A-E)

Fronds up to 3,5 cm high, isolated or sometimes in more or less erect clumps, basal parts semi-endophytic in the tissue of *Lithophyllum incrustans* with young branches protruding *over* host surface. Branching irregularly dichotomous, often in many ranks. Intergenicula terete to subterete, up to 1,5 mm diameter and variable in length, but up to 5 mm long. Intergenicula length may be difficult to discern because genicula are often invisible externally, especially near branch apices. Intergenicula consist of tiers of elongate cells (50) 70-100 (130) µm long, that alternate regularly with tiers of short cells (30) 40-50 (60) µm long. Intergenicular cortices continue growing and older intergenicula are greater in diameter than young ones. Genicula consist of (3) 4-6 (7) tiers of medullary cells (20) 40-80 (130) µm long, the end walls are transverse rather than oblique, and the distal tier is always shorter than the others. Conceptacles are scattered over intergenicular surfaces, they protrude only slightly, and become buried by continued cortical growth. Tetrasporangial conceptacles only observed, c. 200 µm in diameter with bi or tetrasporangia c. 30 µm long and 8 µm diameter.

Habitat

This species was collected only as a semi-endophyte on *Lithophyllum incrustans* Philippi on mid-littoral rocky platforms and shallow pools, in wave-exposed and semi-exposed situations, which are usually influenced by sandy depositions. It is significant that this species is more abundant and frequent on open shores, typically on euryhaline coasts.

Distribution on the European Atlantic coasts (Fig. 2)

SPAIN. **Vizcaya**: Ogeia 30TWP3602, 31-3-1995, on *Lithophyllum incrustans* in mid-littoral pools, *I. Bárbara* (SANT-*Algae* 7297). San Juan de Gaztelugatxe 30TWP1710, 27-11-1991, low-littoral pool, *J.M. Gorostiaga & A. Santolaria*, as *A. beauvoisii* (BIO-*Algae* 079). **Asturias**: Playa del Sarello, Serrantes, 29TPJ6325, 7-8-1990, on *L. incrustans* in

sandy low-littoral pools, *I. Bárbara* (SANT-*Algae* 7298). **Lugo**: Punta Corbeira, Rinlo, Ribadeo, 29TPJ5225, 21-7-1993, on *L. incrustans* in a mid-littoral pool, *A. Granja, J. Cremades & I. Bárbara* (SANT-*Algae* 7486). **A Coruña**: Esteirón, Islas Sisargas, 29TNH1300, 9-10-1994, on *L. incrustans* in a mid-littoral pool, *J. Cremades & A.J. Veiga* (SANT-*Algae* 7039). Camelle, Camariñas, 7-4-1981, *J.L. Maldonado*, as *A. rigida*; *Ibidem*, 7-7-1981, *J.L. Maldonado*, as *A. cryptathrodia* (SANT-*Algae* 7487). Punta Insua, Carnota, 29TMH9035, 6-12-1987, on *L. incrustans* in mid-littoral pools, *J. Cremades & J. Otero*, as *A. subcylindrica* (SANT-*Algae* 5321). Punta Remedios, Carnota, 29TMA8738, 26-12-1987, on *L. incrustans* in mid-littoral pools, *J. Cremades & J. Otero*, as *A. subcylindrica* (SANT-*Algae* 5322). **Pontevedra**: Xidoiro Pedregoso, Ría de Arousa, 24-7-1963, mid-littoral pool, *M. Donze*, as *A. rigida* (L 27924). San Vicente, Ria de Arousa, 7-8-1964, mid-littoral pool, *C. van den Hoek*, as *A. rigida* (L 27923).
PORTUGAL. **Baixo Alentejo**: Praia de S. Torpes, 30-6-1992, *A. Carvalho*, as *A. beauvoisii*. Praia de Vale, 30-6-1992, *A. Carvalho*, as *A. beauvoisii*. Zambujeira do Mar, 28-7-1992, *A. Carvalho*, as *A. beauvoisii*.

Specimens of other taxa examined

Amphiroa beauvoisii Lamouroux

SPAIN. **Cádiz**: Chipiona, 8-1979, *J.E. Hernández Bermejo & T. Gallardo* (SANT-*Algae* 7488). Bahía de Cádiz, 8-9-1986, on *Mesophyllum lichenoides* in low-littoral pools, *J. Cremades & I. Bárbara* (SANT-*Algae* 7485). **Islas Baleares**: Illetas, Mallorca, 11-4-1987, on unidentified Corallinaceae at 1-2m depth, *J. Cremades* (SANT-*Algae* 7483).
PORTUGAL. **Açores**: Punta Delgada, Ilha de San Miguel, 37°44′ N 25°41′ W, 6-6-1981, rocky shore with tidepools and large basin, *G.H. Lokhorst* (L 531851). Porto de Lajes, 38°23′ N 29°15′ W (CANCAP 5 n° 5060, sta. 5.K08) exposed side of small pier, 1-4m. depth, *W.H. Johansen*, as *A. rigida* (L 531860).

Amphiroa rigida Lamouroux

FRANCE. **Pyrénées Orientales**: "Mediterranean, Cette [Sète]" (*Typus*, *ex* Herbier Lamouroux, Herbier de France, PC). "Banyuls sur mer, 24-7-1937, *J. Feldmann*" (*ex* Herbier Feldmann n° 4011, Herbier de France, PC).
SPAIN. **Islas Baleares**: Cala Pi, Mallorca, 14-8-1986, on unidentified Corallinaceae at 1m depth, *J. Cremades* (SANT-*Algae* 7484).

Corallina officinalis Linnaeus

SPAIN. **Pontevedra**: Punta. Campello, Ría de Arousa, 8-7-1963, dredged at 27 m, *M. Donze*, as *A. rigida* (L 27636).

DISCUSSION AND CONCLUSIONS

The morphological and anatomical characters of the specimens studied agree well with the descriptions of *A. van-bosseae* by Lemoine (1929) and Norris & Johansen (1981), although the European plants are not as vigorous as the Pacific ones. However,

European plants occur exclusively as semi-endophytes in *Lithophyllum incrustans* (Fig. 1A). In this, they presumably differ from Pacific ones. The semi-endophytic nature of many species of *Amphiroa* was noted by Cabioch (1969, 1972), who considered the taxonomic identity of the host to be a useful diagnostic feature. For example, *A. rigida* lives basically as a semi-endophyte of *Neogoniolithon brassica-florida* (Harvey) Setchell & Mason [= *N. notarisii* (Dufour) Hamel & Lemoine], *A. verruculosa* Kützing on *Lithophyllum frondosum* (Dufour) Furnari, Cormaci & Alongi (1996) [= "*Pseudolithophyllum expansum* (Philippi) Lemoine"], *A. itonoi* Srimanobhas & Masaki and *A. valonioides* Yendo on other species of *Lithophyllum* (Cabioch, 1969; 1972; Srimanobhas & Masaki, 1987; Choi & Lee, 1989).

The European species that closely resemble *A. van-bosseae* in habit are *A. rigida* and *A. beauvoisii*. However, these two species are anatomically markedly different from *A. van-bosseae*. Study of the type of *A. rigida* (PC) shows that this species has genicula (Fig. 1G) with two tiers of cells 80-125 µm long, united by a very particular imbricated mode and intergenicula alternating 2 (3) tiers of elongate cells with 1 tier of nearly spherical cells (7) 9-10 (12) µm diameter that may be absent at the axial parts. The middle part of the first layer has cells (50) 60-80 (100) µm long and the cells of the second one are (30) 40-60 (80) µm long. *A. beauvoisii* has genicula (Fig. 1H) consisting of 2-3 (4) tiers of non-imbricated cells and intergenicula consisting of (1) 2-3 elongate cells alternating with 1 short cell (Fig. 1I). An additional characteristic of this species is the apparent and progressive flattening of the intergenicula towards the tip.

A. van-bosseae, as we said, has genicula of (3) 4-6 (7) tiers of non imbricated cells, intergenicula with a tier of elongate cells alternating regularly with a tier of short cells and cortex of lower intergenicula with a remarkable and characteristic secondary growth (Fig. 1C-E). The same kind of cellular alternation in intergenicula of *A. van-bosseae* is, interestingly, presented by other two species of the genus on the European coasts: *A. cryptarthrodia* Zanardini and *A. verruculosa* Kützing. Both species, however, have genicula with only 1 or 2 tiers of cells and they are much more slender.

To summarise: *A. van bosseae* is distinguished from the four European species mentioned above by i) having up to 7, but mainly 4-5, tiers of medullary cells in the genicula, ii) having conspicuous secondary growth in the lower intergenicula, and iii) being semi-endophytic in *Litophyllum incrustans*.

A. van-bosseae Lemoine (1929) was considered to be restricted to the Gulf of California and Galapagos Islands (Norris & Johansen, 1981) up to its discovery on the Mauritanian coast (Lawson & John, 1977, as *A. subcylindrica* Dawson; identification confirmed by H.W. Johansen *in litt.*). According to the results presented above (Fig. 2), this species seems also to be frequent on the Atlantic coasts of the Iberian Peninsula where it may have its northern limit of distribution. All the specimens studied down to South Portugal, belong to this taxon, including the herbarium sheets cited as *A. rigida* and the specimens we have collected near the localities mentioned for this taxon in the literature (see Donze, 1968; Ginsburg-Ardré, 1963; Ardré 1969; Pérez-Cirera, 1975; Gorostiaga *et al.*, 1981). This fact suggests that the remaining records from this geographic area probably belong to *A. van-bosseae* as well. From South Portugal to the Strait of Gibraltar most of the bibliographic records belong to *A. beauvoisii*. The specimens from this area available for us to study were also ascribed to this taxon. In this context, the few records of *A. rigida* (Palminha, 1957 and Seoane-Camba, 1965) are difficult to assess due to the abundance of this species on neighbouring Mediterranean coasts.

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REFERENCES

ARDRÉ F., 1969 — Contribution à l'étude des algues marines du Portugal. I. La flore. *Portugaliae Acta Biologica*, sér. B, 10: 137-560.

CABIOCH J., 1969 — Sur le mode de développement de quelques *Amphiroa* (Rhodophycées, Corallinacées). *Comptes Rendus de l'Académie des Sciencies de Paris* 269: 2338-2340.

CABIOCH J., 1972 — Étude sur les Corallinacées. II. La morphogenèse: conséquences systématiques et phylogénétiques. *Cahiers de Biologie Marine* 13: 137-288.

CHOI D.S. & LEE I.K., 1989 — Notes on *Amphiroa* (Rhodophyta) from Cheju Island. *The Korean Journal of Botany* 32 (4): 363-373.

DAVEAU J., 1884 — Contribuçoes para a flora de Portugal I. Excursion botanique aux Iles Berlengas et Farilhoes. *Boletim da Sociedade Broteriana* I (2): 13-31.

DAWSON E.Y., 1953 — Marine Red Algae of Pacific Mexico. Part I: Bangiales to Corallinaceae Subf. Corallinoideae. *Allan Hancock Pacific Expeditions* 17: 1-240.

DONZE M., 1968 — The algal vegetation of the Ria de Arosa (NW. Spain). *Blumea* 16: 159-192.

FURNARI G., CORMACI M. & ALONGI G., 1996 — *Lithophyllum frondosum* (Dufour) comb. nov. (Corallinaceae, Rhodophyta): the species to wich Mediterranean "*Pseudolithophyllum expansum*" should be referred. European. *Journal of Phycology* 31: 117-122.

GINSBURG-ARDRÉ F., 1963 — Algues du Portugal: Liste préliminaire, II. *Revue Générale de Botanique* 70: 371-381.

GOROSTIAGA J.M., ANGULO R. & IBÁÑEZ M., 1981 — Nueva cita de *Saccorhiza polyschides* y *Laminaria ochroleuca* en la Costa Vasca. *Lurralde* 4: 265-270.

IBÁÑEZ M., ANGULO R. & IRIBAR X., 1980 — *Biogeografia de la Costa Vasca*. L. Haramburu, San Sebastián, 284 p.

LAWSON G.W & JOHN D.M., 1977 — The marine flora of the Cap Blanc peninsula: its distribution and affinities. *Botanical Journal of the Linnean Society* 75: 99-118.

LEMOINE M. (Mme P.), 1929 — Les Corallinacées de l'archipel des Galapagos et du Golfe de Panama. *Archives du Muséum d'Histoire Naturelle* (Paris), sér. 6, 4: 37-86.

NORRIS J.N. & JOHANSEN H.W., 1981 — Articulated coralline algae of the Gulf of California, Mexico, I: *Amphiroa* Lamouroux. *Smithsonian Contributions to the Marine Sciences* 9: 1-29.

PALMINHA F.P., 1957 — Contribuições para o estudo das algas marinhas portuguesas. II (Litoral Algarvio). *Boletim da Sociedade Portuguesa de Ciências Naturais* 7, sér. 2, 22: 68-74.

PÉREZ-CIRERA J.L., 1975 — Catálogo florístico de las algas bentónicas de la Ria de Corme y Lage, NO. España. *Anales del Instituto Botánico A.J. Cavanilles* 32 (1): 5-87.

SAUVAGEAU C., 1897 — Note préliminaire sur les algues marines du Golfe du Gascogne. *Journal de Botanique* 11: 1-64.

SEOANE-CAMBA J.A., 1965 — Estudio sobre las algas bentónicas en la costa sur de la Peninsula Ibérica (litoral de Cádiz). *Investigación Pesquera* 29: 3-216.

SRIMANOBHAS V. & MASAKI T., 1987 — *Amphiroa itonoi* (Corallinales, Rhodophyta), a new species of marine algae from Japan. *The Japanese Journal of Phycology* (Sôrui) 35: 1-9.

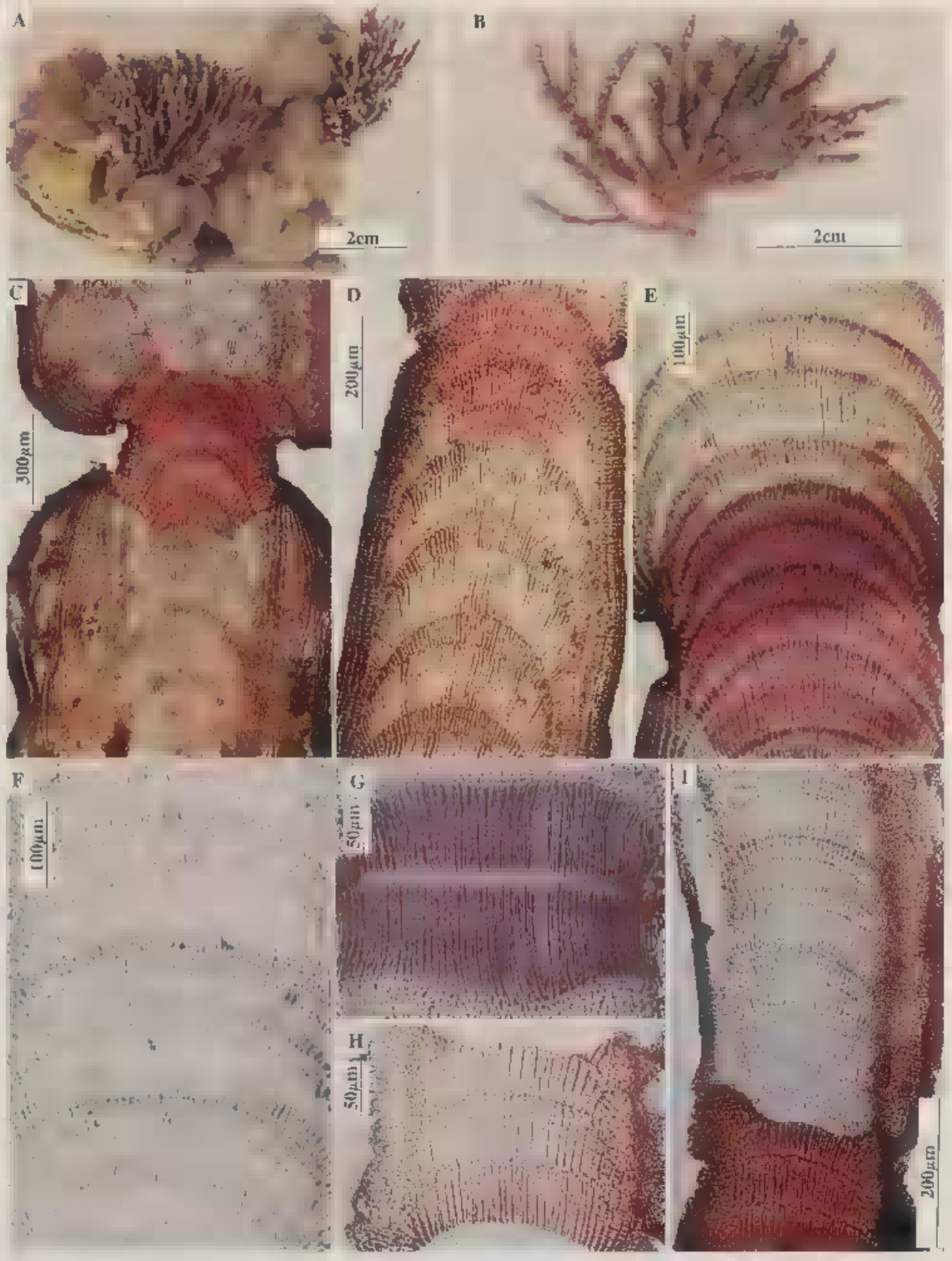

Fig. 1. *Amphiroa van-bosseae* (SANT-*Algae* 5321). A, habit of some specimens growing on *Lithophyllum incrustans*; B, frond with numerous conceptacles showing branching pattern; C, Intergenicular longitudinal section of ■ basal branch with strong cortical thickening, several asexual conceptacles buried in the calcified tissue and ■ 5-tiered geniculum; D, young branch showing the unusual arrangement of alternating long and short tiers of medullary cells and a 4-tiered geniculum; E, 6-tiered geniculum. *Amphiroa rigida*: F, intergeniculum with two tiers of long cells alternating with one of short ones (SANT-*Algae* 7484); G, characteristic two-tiered geniculum in which the end walls of the cells are slanted and appear to overlap (*Typus*, PC). *Amphiroa beauvoisii* (SANT-*Algae* 7483): H, 3-tiered geniculum; I, middle branch showing a 3-tiered geniculum and the cellular arrangement of the intergeniculum, 2-3 tiers of long cells alternating with one of short ones.

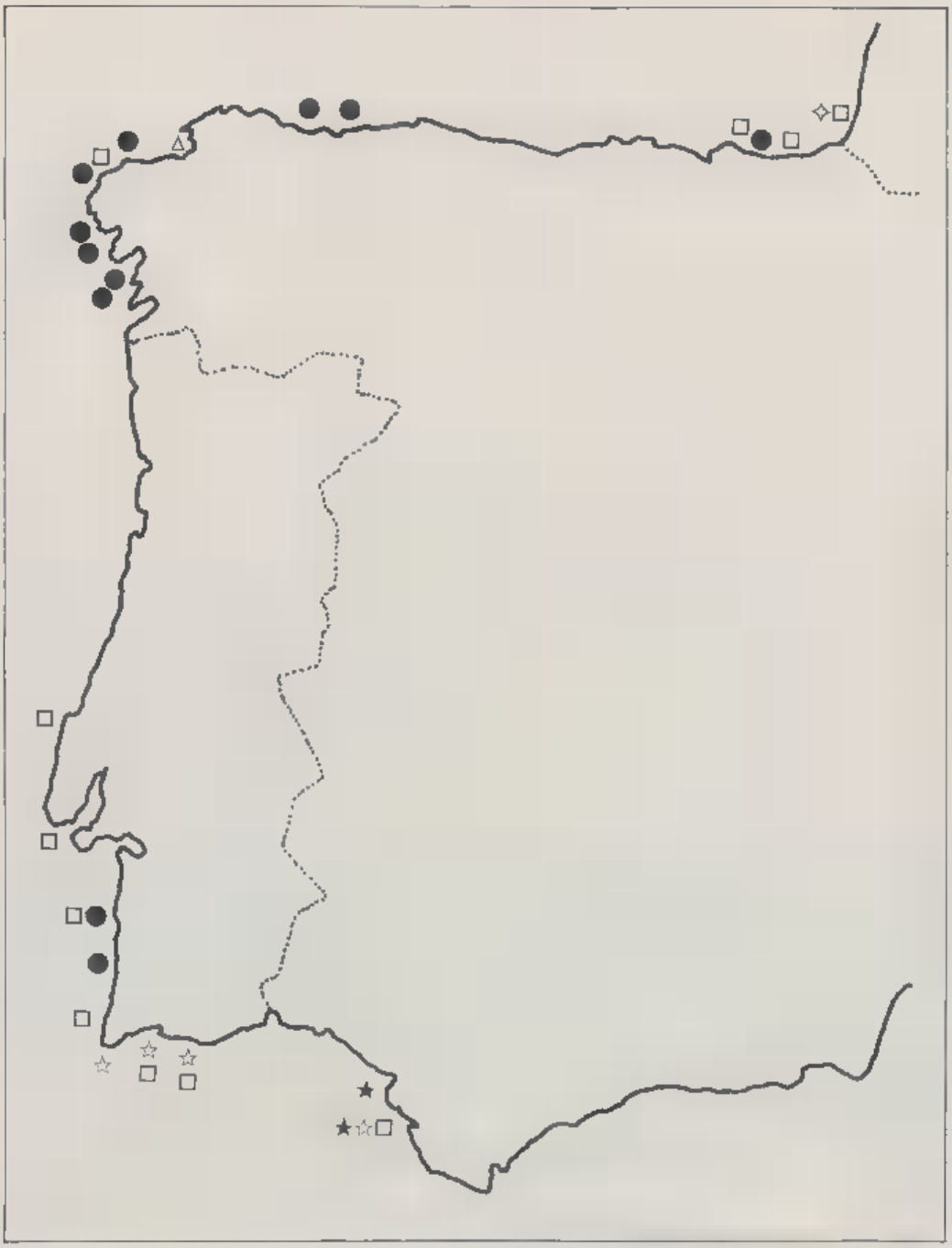

Fig. 2. Distribution of *Amphiroa* species on the European Atlantic coasts. ●, *A. van-bosseae*; □, *A. rigida*; ☆, *A. beauvoisii*; ✧, *A. cryptarthrodia*; Δ, *A. verruculosa* (empty symbols: bibliographic reports; full symbols: specimens studied).